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The Prevalence, Characteristics and Impact of Head Injury in Female Prisoners: A Systematic PRISMA Review

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Abstract

Background: Although head injury (HI) is associated with offending behaviour, there has been relatively little attention to female prisoners. This systematic review considers the prevalence and characteristics of females with HI in prison, with a view towards improving understanding of service needs.

Methods: Electronic databases were searched and two meta-analyses and two systematic reviews were checked for further relevant papers. Studies describing prevalence of HI in female prisoners were included. Papers were assessed for risk of bias.

Results: Twelve studies were included. Prevalence of HI ranged from 19%-95% and was lower in studies using hospital records than self-report and generally did not differ by gender. Risk of bias was high overall, with little consistency in assessment methods and definition of HI. Samples sizes of female prisoners with HI were often modest and not clearly representative of the population.

The experiences/needs of prisoners can differ by gender, with females having a higher risk of physical and mental health problems, including psychological trauma.

Conclusion: HI is prevalent in female prisoners, and their needs and experiences may differ from male prisoners with HI and female prisoners without. There are limitations in the literature, and future research should address these, and in so doing develop a firm, evidence base upon which effective services and interventions for female prisoners with HI can be developed.

Introduction

Evidence for an association between head injury (HI) and offending is mounting (1). Two meta-analyses on prisoners with HI estimated a lifetime prevalence of 51% (2) and 60% (3) on the basis of self-report and a recent national prison population study as 25% on the basis of lifetime hospital admissions (4). These figures are high compared to an estimated prevalence of HI of 12% in the general population (5).

Psychological changes associated with HI, such as increased impulsivity, impaired cognition (including reduced mentalisation capacity) and social disability (6-8) may precipitate offending behaviour, and this raises important questions about delivery of health

services for those with HI in prison settings (9). In this review, the term HI is preferred to traumatic brain injury (TBI) because in most instances, studies are based on self-report where the occurrence of an injury to the head may be likely, but brain injury is inferred and might not have occurred (10). Also, data linkage studies on hospitalisation use ICD codes which are designated as ‘head injury’ and again it is not clear whether TBI has occurred for some codes (4).

The meta-analysis by Shiroma et al (3) reviewed 20 studies published up to 2009, and these comprised 4365 participants in total. They considered gender separately, combining four studies, with a total sample of only 387 females. The prevalence of HI was 55% in females reporting loss of consciousness (LOC) and was similar in males (59%) with standard errors comparable in both groups. However, the literature on HI in prisoners generally tends to report data for males only. Farrer and Hedges (2) included 24 studies in their meta-analysis on prevalence of HI in incarcerated groups in a range of institutions. Data on females were reported in less than half of the studies and gender was not considered separately in this meta-analysis. A recent systematic review investigated HI and co-occurring problems in prisoners (11). It briefly reported the female literature and concluded that the needs of female prisoners with HI differ from their male counterparts. However, it did not consider risk of bias in included studies and did not comment on whether the needs of female prisoners with HI might differ from non-HI females. Overall, the gender bias in this research is probably due to the relatively small number of female offenders in the prison population, making it more difficult to collect sufficient female data for separate analysis (12).

Although, reviews suggest a high prevalence of HI in offenders, including in females, it would be inappropriate to attempt to address their health needs on the basis of research that is predominantly on males. Hence, this systematic review evaluates whether the needs of female prisoners with HI are distinct and if so, factors that prisons may need to consider in terms of service provision.

Review questions

1. What is the prevalence of HI in female prisoners?
2. How unique are the characteristics and epidemiology of female prisoners with HI?
3. What is the ongoing impact of HI upon female prisoners, in terms of impairment and disability?

Methods

Protocol and registration

The protocol for this review was not registered.

Eligibility criteria

Studies were included if separately describing data on HI in a female prisoner population. Cross-sectional and cohort studies published in a peer-reviewed journal, printed in English and which ascertained lifetime history of HI were included. Studies based on birth cohorts were excluded because of difficulty in extrapolating to service needs in a prison population. Given that this review considers the prevalence of HI in female prisoners, studies with a very small female sample ($n < 10$) were excluded because of an implicitly high risk of bias.

Information sources

The following databases were searched for all research published by the 31st January 2019: Ebsco PsycINFO, Ebsco CINAHL, Ovid EMBASE, Ovid Medline, Web of Science and Wiley Cochrane Library. Figure 1 outlines the process of eliminating non-

relevant papers (following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (13-14). Duplicates were removed prior to references being retrieved for review.

Search

The following text word searches were chosen from terms used in relevant published systematic reviews (10, 11, 15).

1. ((“Traumatic Brain Injury” OR TBI OR “Head Injur*”))
2. ((crim* OR inmate* OR prison* OR offend*))
3. ((sex OR gender OR female OR wom?n))
4. 1 AND 2 AND 3

To search for the phrase ‘Traumatic Brain Injury’, the following terms were used: “Traumatic Brain Injury” in EBSCO, OVID and Web of Science and *Traumatic Brain Injury* in Wiley Cochrane Library. Additionally, the papers included in two meta-analyses (2-3) and two systematic reviews (11,15) were reviewed and as a result, four articles reporting female data were found that were not identified by the initial search. Text word search 3 was then removed and the search was repeated as follows:

1. ((“Traumatic Brain Injury” OR TBI OR “Head Injur*”))
2. ((crim* OR inmate* OR prison* OR offend*))
3. 1 AND 2

This revised search detected the four papers missing in the original search. This occurrence is perhaps symptomatic of gender not being included routinely in article keywords, titles or abstracts.

After removing duplicates, 1182 articles were identified. On screening for relevance using the eligibility criteria, 1070 were excluded by title and a further 77 by abstract. Thirty-five articles were read in full. Of these, 22 were excluded (see figure 1); 14 did not separately report female data, two reported HI in females as a covariant only (16, 17), two did not ascertain lifetime exposure to HI (18, 19), one had a female sample of less than ten (20), two did not sample from a prison population (21, 22) and one did not assess HI (23). Thirteen articles were included in the final review (see figure 1). Two articles describe different aspects of the same study (24, 25); both are relevant and are included as a single study.

Figure 1 about here please

Quality rating

Seven domains were derived from criteria developed for assessing risk of bias in observational studies in epidemiology (26). Domains were based on a previous systematic review of HI and offending (10) and modified in relation to the review questions (see table 1). These domains were used to organise and synthesise the data across studies. Domains were categorised as ‘high’ or ‘low’ in risk of bias according to criteria in table 1. Where data on HI were collected for females but not reported separately, domains were categorised as ‘not reported’ (N/R). Where domains did not apply to a study, they were categorised as ‘not applicable’ (N/A). Articles were rated on each domain independently by the two authors (TM/AM). There was inter-rater concordance between the authors for 79/84 ratings (94%). The five exceptions were resolved by discussion.

Table 1 about here please

Results

Nine of the twelve studies investigated adults in prison and three, juveniles in prison (27-29). One was a national prison population study that included adults and juveniles (4). One further study included adults and a single juvenile prisoner; only the adult data were considered in this review (30; see table 3). All but one study (30) indicated the number of female participants with HI. The median number of female prisoners was 104 (range 29-316) and the median number of female prisoners with HI, 41 (range 21-228). Overall, risk of bias was low for participant selection and high for assessment of the prevalence of HI and for control of confounding variables, where for example, none controlled for potential effects of current substance misuse. Risk of bias was mixed for other domains, with the exception of assessing the prevalence of disability, which was not assessed in any study (table 2).

Table 2 about here please

Methods for selecting study participants

Risk of bias was generally low, with detailed inclusion and exclusion criteria provided in all but two studies (27, 32).

Methods for assessing the prevalence of HI in female offenders

A wide range in prevalence of HI of any severity is reported (19%-95%). It is lower in the study using hospital records (19%) (4), than in the others which used self-report (23%-95%). There was high risk of bias in all but one study where the sample size was modest (n=38) and the prevalence of HI (by self-report) the highest of all studies (95%) (32). Studies on juvenile females report a prevalence of 28%-49%, with one study reporting a prevalence of HI with LoC of 49% (27-29). Overall fewer than half of the studies (28, 29, 32, 34) reported severity of HI using internationally recommended definitions (35) and only four studies (24/25, 27, 32, 33) used a HI screening tool that is validated for a prison population. Moderate-severe HI (LoC > 30 minutes) was reported as

22% and 37% in two adult studies (32, 34) and 12.5% in one juvenile study (28). Another considered lifetime hospital admissions with HI in the population of females in Scotland who were under the age of 36 years and in prison (n=248) using ICD codes, and reported a HI prevalence of 19% (4).

Seven studies compared the prevalence of HI in males and females. Gender differences in prevalence were non-significant in most studies (4, 27, 28, 30, 34). Others had a high risk of bias and reported a higher prevalence of HI in both females (24/25) and in males (31). Few studies included non-prisoner comparison groups. A data linkage study on the prevalence of hospitalised HI in prisoners, found HI in female prisoners (19%) to be more common than in a general population comparison group matched for age, gender and social deprivation (10%) (4). Unsurprisingly, O'Rourke et al (33) found a higher occurrence of HI in women prisoners than in a University sample.

Overall, the prevalence of HI seems similar in female and male prisoners and higher than in the general population.

Methods for assessing the uniqueness of the epidemiology and characteristics of female prisoners with HI

Seven studies report epidemiological characteristics in adult female prisoners with HI. Two low bias studies looked at age at first HI; one found females to be older than males (24/25) and the other no difference (34). Two low bias studies report no gender difference in the number of HI sustained (30, 31). Of three low bias studies considering HI severity, two report no gender difference (30, 34) and one that females are less likely to report HI with LoC (24/25). Two low bias juvenile studies (27, 28) report no gender difference in severity or number of HI. Three low bias studies (28, 30, 31) and one high bias study (36) found that assault was the most common cause of HI in females. Moore et al (28) note that young females were more likely to report a recent HI (< 6 months prior to interview) than young males.

One adult (34) and one juvenile study (27) that were low in risk of bias and two high risk adult studies (32, 33) examined health characteristics. Use of alcohol and drugs, was more common in females than in males with HI in one study (34) and mental health problems including anxiety, was common in females with HI in another (32). Juvenile females were more likely than males to use mental health services (27). Females with HI more often reported a history of physical and sexual abuse than females without HI or than males with HI (34). O'Rourke et al (33) report a high occurrence of past mental health problems by self-report and of childhood and adult experiences of physical and sexual abuse using the Abusive Behaviour Inventory and the Childhood Trauma Questionnaire. Their comparison group of female University students does not seem pertinent given differences in educational and social background and their unexpectedly high occurrence of HI (35%). Nevertheless, the occurrence of trauma was notably common in female prisoners with HI (e.g. adult physical abuse 68%).

In relation to offending behaviour, there are three low (27, 33, 36) and one high bias study (34). One study found that HI was more common in violent than in non-violent female prisoners (36), and one found no difference between female prisoners with HI and females without HI or males with HI (34). Females were significantly more likely to report that HI occurred prior to their first criminal involvement than males in one study (34). O'Rourke et al (33) reported that 57% of female offenders reported experiencing their first HI prior to their first conviction, although there was no comparator group. Finally, one juvenile study found that females with HI are less likely to recidivate than males with HI (27).

Methods for assessing the prevalence of impairments/complaints after HI in female prisoners

One low bias study used the Buss Perry Aggression Questionnaire and Abbreviated Dysregulation Inventory and controlled for cognitive and emotional dysregulation; aggression was associated with HI in males but not females (24/25). A high bias study reported that females who sustained their first HI before 9 years of age were more likely to report anxiety and stress than those with HI at an older age (32).

Two low bias adult (24/25) and juvenile studies (27) and one high bias juvenile study (28) looked at symptom reporting. All three found females to be more likely to report ongoing symptoms than males after HI, with the two low bias studies reporting significant differences. Only Kaba et al (27) used a validated outcome measure (TBIQ) but did not give a breakdown of specific symptoms. Fishbein/Ferguson (24/25) noted self-report of ‘neurological effects’ to be more common in females than males with HI (headaches, problems with memory, concentration, coordination or balance).

Methods for assessing the prevalence of disability after HI in female prisoners

No studies reported disability after HI.

Design-specific confounders

In terms of the representativeness of samples, only one study was low in risk of bias and representative (4); two others (30, 36) state that their sample was representative, but did not provide supportive data. Two studies were not demographically representative (24/25, 31) and the others did not report representativeness.

Methods to control confounding

One high bias study used medical records to corroborate self-report (36), but there is no clarity around the type of records used and whether they accessed records for all participants (see table 3). One study data linked prisoners to records of hospitalisation (4). No studies appear to have used blinding in outcome assessments and none controlled for potential confounders of HI outcomes or factors associated with offending such as current substance use. Therefore, all studies are at high risk of bias in this domain.

Table 3 about here please

Discussion

What is the prevalence of HI in female prisoners?

The meta-analysis reporting pooled prevalence of HI separately by gender on the basis of four studies (31, 36, 37, 38), suggests that 55% of female prisoners have a history of HI (3). However, it did not assess study quality or bias. In this SR we included two of these papers reviewed by Shiroma et al (31, 36) and excluded two which were unpublished (37, 38). We reviewed 11 other studies published since 2009. In the present review, only one study on the prevalence of HI was low in risk of bias and the sample was modest (32). Indeed sample size is a recurring issue when attempting to establish the prevalence and epidemiological characteristics of female prisoners with HI, with the median being only 41. In general, studies report a wide range in prevalence of HI assessed by self-report in female prisoners (23-95%) and this may reflect the high risk of bias in these studies. However, it should be noted that even the lower estimates are higher than expected in the general population (12%) (5), including for matched comparisons in the hospitalised HI data linkage study (10%) (4). In the data linkage study, the prevalence of HI in females (19%) is likely to be lower than for self-report given that offenders do not always attended hospital after sustaining a HI (39). Most studies suggest that the prevalence of HI in male and female prisoners is similar (4, 27, 28, 30, 34). This is of note given that the risk of HI in men in the general population is two-fold that of women (5). Although the overarching high risk of bias makes it difficult to reach a firm conclusion about prevalence of HI in female prisoners, even at lower estimates it is high and more common than found in the general population.

How unique are the characteristics and epidemiology of HI in female prisoners with HI?

Studies that are low in risk of bias suggest that the epidemiology of HI in prisoners differs by gender. Female prisoners may be older at first HI than male prisoners (24/25) and more likely to report assault as the cause (28, 31). There is less consistency about the number and severity of HI (24, 30, 31, 34). All studies here are limited by the absence of matched controls, use of unrepresentative samples, and failure to control for potential sources of confounding including use of a range of definitions and means of assessing the occurrence of HI and its severity. Hence, although there are indications that some epidemiological characteristics of female prisoners with HI differ from male prisoners, caution is required given the limited evidence base.

There are some indications that other characteristics of female prisoners with HI differ from their male counterparts with HI and from females without. Complex trauma seems more common in female prisoners and is associated with a history of physical and sexual abuse including in childhood (32, 33, 34). This may be important in relation to formulation of interventions for mental health problems. Adult studies report poor physical and mental health, and alcohol and substance misuse as being common in females with HI (32, 34). In a similar vein, one juvenile study found that females with HI used mental health services more often and were less likely to recidivate than their male counterparts (27). In summary, the characteristics of female prisoners with HI may be unique and differ from male prisoners with HI and from female prisoners without HI, and as such they will have different support needs. However, although most relevant studies were low in risk of bias in this domain, interpretation of findings is complicated by a high risk of bias in other domains, such as sample representativeness and definition of HI and further research is needed.

What is the impact of HI on impairment and disability in female prisoners?

There is a dearth of research on the persisting effects of HI on everyday function in female prisoners and especially in relation to disability. Female prisoners can report more ongoing symptoms after HI than males (27, 28, 32) but the evidence is modest with only one study (27) using a validated measure of symptom reporting. A study that did use validated measures of cognition and mental health reported less aggression in females than in males with HI, after controlling for cognitive and emotional dysregulation

(24/25). Overall, the impact of HI on female prisoners may differ from male prisoners and may therefore be relevant to service needs, but findings require replication using validated measures and studies on disability outcome are needed.

Juvenile prisoners

Few studies report the effects of HI in female prisoners, and those that do are subject to high risk of bias in the majority of domains (27, 28, 29). It may be that the prevalence of HI in female juveniles is lower than in adults, but this may simply reflect age related differences in exposure to risk. There is some suggestion that there are not gender differences in juveniles in prevalence or in the number and severity of HI. Although one low bias study (27) suggests that female juvenile prisoners with HI are less likely to recidivate than male counterparts and more often report mental health problems and persisting symptoms, this requires replication.

Limitations of the review

The included papers were co-rated for risk of bias, but review by title and abstract for relevance was carried out by a single author. The authors did not obtain access to gender specific data that was collected in some studies but not presented in their publications.

Clinical implications and recommendations

Current findings suggest important clinical and legal implications if confirmed in future. These include implications for interagency working between prison and health services, and future service planning and provision. There is already awareness of a high occurrence of psychological trauma and abuse among the female prison population (40). If the prevalence of trauma, mental and physical health issues, and substance misuse is higher among female prisoners with HI than in their non-HI counterparts, there may be greater need for triage and access to trauma-informed services that provide psychological therapy and support, including from third sector organisations (9). Further, there may be responsivity issues to consider in relation to the effects of HI on cognition and

everyday function (8). Psychological interventions may need to be adapted to meet the needs of this population, and to consider how effects of HI factors might affect ability to engage with and respond to therapy (41).

Finally, there may be implications for how females are managed within the broader criminal justice process, and special provision and considerations may be appropriate. For example, the introduction of HI screening within custody suites and in courts (9). This may inform decision-making around specific needs and interventions to be addressed in prison or probation settings. It may also inform adjustments and adaptations required to ensure that these females are given opportunities for fair and effective participation in the court process (42).

Future research

In order to establish the clinical and legal implications arising from HI in female prisoners, further research is needed. This work should recruit female samples that are demographically representative of the wider prison population, and make comparisons between prison and general population samples. This will enable more confident estimates of prevalence and provide a stronger basis from which to determine the characteristics of this population, and ways in which their needs may differ from prison and non-prison populations more generally. HI self-report needs to be compared with hospital records to gain understanding of the reliability of self-report and circumstances where females are less likely to attend hospital after HI. Studies should also control for potentially confounding factors when attempting to understand the unique contribution of HI to outcome. There is a need to take a uniform approach to the definition of HI severity in line with internationally established cut-offs, and to use validated tools which align with these established cut-offs, such as the Ohio State University Traumatic Brain Injury Identification Method (43). Finally, HI-associated disability should be assessed using a validated tool, such as the Glasgow Outcome at Discharge Scale to facilitate

appropriate triage to intervention and support (44). In these ways, between-study comparisons will have greater validity, which in turn will facilitate the development of good practice.

There are also barriers to research in this area that require foresight. Some of these are not unique to females, such as negotiating formal and informal gateways to gain access to prisons for research purposes, security and logistical issues related to accessing prisoners and a need to work in partnership with prison management, staff, and prisoners who can be sceptical about the benefits of research and not understand the rationale for procedures. These pitfalls can be reduced by consistent and regular communication with relevant parties, developing adequate knowledge of individual prison systems, complying with security procedures and being transparent to both staff and participants about the overall aims of the research. Female prisoners are a vulnerable population, and care must be taken to undertake research in a trauma-informed manner. As such, informed consent should be a priority, care should be taken to use appropriately trained and skilled researchers and links need to be established with prison health services in the event of significant issues being uncovered. Even then, the research design must take account of the often limited mental health support available to prisoners, and should research assessments expose issues for prisoners for example in relation to trauma, there may be no service available to help with this unless negotiated with prison health services.

Conclusions

Research on female prisoners with HI is limited by a high risk of bias. As a result the current paper is limited in the extent to which it can draw firm conclusions in relation to the review questions. Clearly though, HI is prevalent in female prisoners, and evidence points towards needs and experiences that may be unique compared to females without HI and male prisoners with HI. Studies with low risk of bias suggest that prison services for females with HI may require specific consideration (e.g. the need for trauma-

informed services). There is little evidence regarding ongoing impact of HI, especially in relation to disability, making recommendations about service needs difficult. Future research should resolve the limitations in the current literature, with an overall aim of building a firm, scientific evidence base upon which services and interventions for female prisoners with HI can be developed.

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Table 1. Domains and criteria for assessing risk of bias

Domain	Criteria
1. Methods for selecting study participants	Inclusion and exclusion criteria are clear.
2. Methods for assessing the prevalence of HI in female prisoners	<ul style="list-style-type: none"> (i) Use of a HI assessment tool that is validated for HI and preferably in a prison population (ii) Use of internationally recognised HI definition and cut-offs for HI severity (iii) Assessment of the number and severity of HI
3. Methods for assessing uniqueness of the epidemiology and characteristics of female prisoners with HI	Age, social deprivation, age at first/only HI, cause number and severity of HI, comorbidities including substance abuse, mental health and trauma, forensic history including recidivism and in-prison behaviour/incidents. Compared with at least one but preferably all of the following: females in the general population with HI and male prisoners with HI and female prisoners without HI.
4. Methods for assessing the prevalence of impairments/complaints after HI in female prisoners	<ul style="list-style-type: none"> (i) Use a validated tool for assessing outcome after HI (e.g. mental health or neuropsychological impairment). (ii) Compare the prevalence of HI in female prisoners to those without HI and/or male prisoners with HI
5. Methods for assessing the prevalence of disability after HI in female prisoners	<ul style="list-style-type: none"> (i) Use a validated tool for assessing outcome after HI.

	(ii) Compare the prevalence of disability in female prisoners with HI to those without HI and/or male prisoners with HI
6. Design-specific confounders	<p>The sample is demographically representative of</p> <ul style="list-style-type: none"> (i) the offender population from which it is taken (e.g. a particular prison) (ii) the offender population in the prison service; e.g. a state or country. (iii) to consider any other confounders
7. Methods to control confounding	Specific to the study design and relevant to the review questions such as blinding of raters to study-specific questions and consideration of potentially confounding by factors such as current substance abuse and cross-reference of self-report with hospital records, especially for more severe HI.

Table 2. Risk of bias

	1. Methods for selecting study participants	2. Methods for assessing the prevalence of HI in female offenders	3. Methods for assessing uniqueness epidemiology and characteristics of female prisoners with HI	4. Methods for assessing the prevalence of impairments/complaints after HI in female prisoners	5. Methods for assessing the prevalence of disability after HI in female prisoners	6. Design-specific confounders	7. Methods to control confounding
Brewer-Smyth et al (36)	LOW	HIGH	HIGH	N/A	N/A	HIGH	HIGH
Colantonio et al (34)	LOW	HIGH	LOW	N/A	N/A	HIGH	HIGH
Diamond et al (31)	LOW	HIGH	LOW	N/R	N/A	HIGH	HIGH
Durand et al (30)	LOW	HIGH	LOW	HIGH	N/A	HIGH	HIGH
Fishbein et al (24)/ Ferguson et al (25)	LOW	HIGH	LOW	LOW	N/A	HIGH	HIGH
Gordon et al (29)	LOW	HIGH	N/R	N/A	N/A	HIGH	HIGH
Kaba et al (27)	HIGH	HIGH	LOW	LOW	N/A	HIGH	HIGH
McMillan et al (4)	LOW	HIGH	N/R	N/A	N/A	LOW	N/A
Moore et al (28)	LOW	HIGH	LOW	N/R	N/A	HIGH	HIGH

Table 3. Summary of included papers

Reference	Country, sample size and institution	Sample Characteristics	HI measure and definition	Prevalence of HI in female prisoners	Epidemiology/characteristics of female prisoners with HI	Impairments/complaints after HI in females	Prevalence of disability
Brewer-Smyth et al (36)	USA; 133 adult females; minimum and maximum security units of a women's prison	Age (mean) 32.9	Measure: Self-report interview corroborated by criminal and medical records (where available), physical evidence of injuries/deficits – examination carried out (three-word recall, cranial nerves, extremity strength, coordination, gait) Definition: Any HI with LoC	42%	No comparison to male prisoners The number of HI was higher for violent than non-violent offenders Most HI occurred as a result of violence and/or during high-risk behaviours, such as substance abuse	Not assessed	Not assessed
Colantonio et al (34)	Canada; 104 female and 131 male; 3 male and 1 female prison	Age (mean): female HI 35.1; no HI 33.6 Male HI 32.5; no HI 36.6	Measure: Self-report interview Definition: Any HI, with or without LOC LoC < 30 = mild; LoC > 30 = mod/sev	38% overall HI with LoC, n=27	Females more likely than men to have had HI prior to criminal involvement After first HI, females higher risk of substance abuse and alcohol use than men Females with HI higher rates of abuse than females without HI and males overall	Not assessed	Not assessed
Diamond et al (31)	USA; 118 females and 107 males; 6 low, medium, and high security prisons.	Age (mean): female 36; male 34	Measure: Traumatic Brain Injury Questionnaire Definition: Any HI, with or without LoC Suspected/minimal HI: no reported alteration of consciousness/PTA Mild HI: LoC < 1 hour, PTA < 1 day Mod/sev HI: LoC > 1 hour, PTA > 1 day	Not reported separately for gender.	No difference in number of HIs in males and females More females than males reported assault as cause of HI Females less likely than males to report HI with LoC.	Not reported separately	Not assessed
Durand et al (30)	France (Paris); 88 adult and 12 juvenile females; sentenced or on remand in prison	Age (mean), adult 32.4, juvenile 15.5	Measure: Self-report interview Definition: All HI with or without LoC	23% HI with LoC, n=8	No gender difference in cause or severity of HI or age at first HI Violence (35%) most common HI cause in females	Not assessed	Not assessed

			Severe : coma Moderate: hospitalization without coma Mild: all other HI				
Fishbein et al (24)/ Ferguson et al (25)	USA (S Carolina); 316 female and 320 males in prison	Age (mean), females 36.1, males 34.8	Measure: OSU TBI-ID* Definition: All HI with or without LOC	72% HI with LoC, n=150	Older age at first HI and HI with LoC more common in females HI more common and severe in females than males for release. The opposite for non-release prisoners. More females than males reported HI before age 15. An exception in release prisoners, where more males had HI with LoC before age 15.	Female gender associated with lower total aggression after cognitive and emotional dysregulation taken in to account 55% of female releases and 58% of non-releases reported ongoing symptoms from HI on a checklist	Not assessed
Gordon et al (29)	USA (Texas) 3038 male 308 female juveniles in correction centres	Age (both genders) 15.8 (range 10-22 yr)	Measure: Brain Injury Screening Questionnaire Definition: A blow to the head and LoC or being dazed and confused. Mild: LoC < 30 minutes Moderate-severe: LoC > 30 minutes	28%	HI more common in females (28%) than males (21%). Other details not given	Not assessed	Not assessed
Kaba et al (27)	USA (New York) 84 female and 300 male juvenile prisoners in NYC Department of Correction facility	Age (mean), 17.1	Measure: TBIQ Definition: One or more HI with LoC/PTA	49%	Same proportion of males and females with no injury (30%), multiple mild HI (20%), and one or more HI with LOC/PTA (49%). No comparison with females without HI HI females significantly more likely to use mental health services than HI males	HI females reported higher scores than HI males on TBIQ symptom severity and frequency scales	Not assessed

					HI females significantly less likely to reoffend than HI males		
McMillan et al (4)	Scotland (entire prison population aged <36 years) 248 females 4126 males and 3 general population controls per prisoner matched for age, gender and social deprivation	Not reported	NHS unique identifier and health record database linkage Definition: ICD-9 800, 801; 803, 804 and 850-854; ICD-10 S02.0, S02.1, S02.3, S02.7-S02.9, S06.0-S06.90, S09.90. ICD codes for intracranial injury (ICD-9 851-854; ICD-10 S06.1-S06.9) except concussion, used to indicator 'more severe' HI	Female prisoners 19%; controls 10% (Male prisoners 25%; controls 19%)	No gender difference in prevalence of HI	Not assessed	Not assessed
Moore et al (28)	Australia; 39 female and 277 male juveniles in detention centres	Age (mean), 17.0	Measure: Self-report interview Definition: HI with LoC Mild: LoC < 30 Moderate/severe: LoC > 30	33%	No gender difference in prevalence of HI Females more likely to report recent HI than males Females more likely to report assault as cause than males	Validated outcome measures not reported separately. Females self-reported ongoing neurological effects of HI significantly more frequently than men	Not assessed
Nolan and Stewart (45)	Canada; 280 convicted females newly admitted to institutions (compared to 773 males in earlier study; Stewart et al, 2015)	Age (median), 31.5	Measure: Comprehensive health assessment questionnaire Definition: Not provided	23% female (34% male)	Not assessed	Not assessed	Not assessed
O'Rourke et al (33)	UK single prison; 29 female prisoners compared to 29 University sample	Age (mean 32 prisoners and 29 University controls)	Measure: Brain Injury Screening Index	72% prisoners (65% with LoC) 35% controls (34% with LoC)	Prisoners with HI were: less well educated, first HI at older age, more repeat HI. Self-report of drug/alcohol abuse, mental health problems and physical or sexual abuse as child or adult more common in prisoners	Not assessed	Not assessed

Woolhouse et al (32)	New Zealand (Christchurch); 38 females in prison	Age (mean), 33 (range 13-71) IQ: 86 (55-115)	Measure: OSU TBI-ID* Definition: Mild: LoC < 30 Moderate/severe: LoC > 30 min	95% (83% of which reported multiple injuries)	No comparison to male or female prisoners Domestic violence cause of 12% of HI At least one HI caused by assault from a parent/partner in 26%	No comparison with males or female prisoners. HI prior to age 9 associated with more impairment (eg anxiety, stress) than later HI	Not assessed
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*Ohio State University Traumatic Brain Injury-Identification Method